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ESTIMATING HUMAN AND PHYSICAL CAPITAL STOCKS IN DATA-SCARCE ENVIRONMENTS: A METHODOLOGICAL NOTE AND APPLICATION TO GUATEMALA

LOENING, Josef L.[1]

Abstract

This paper presents a methodology to construct time series of human and physical capital, taking into consideration the data-scarce environment of a developing country. A particular focus is placed on the construction of the human capital stock, which is defined by average years of schooling. For the case of Guatemala, a country which is deficient in easily accessible data even within the Latin American context, the paper shows how reliable time series can be obtained for the period 1950-2002. As such, the results of this paper may be useful for data-generating exercises in developing countries with similar constraints. Moreover, the estimates presented here provide a valuable starting point for future regression or growth accounting analyses.

JEL classification: I20, J24, N36.

Keywords: Human Capital, Physical Capital, Economic Growth, Guatemala.

1. Introduction

Researchers interested in time-series analysis of developing countries typically face data limitations. The special case of Guatemala, presented in this paper, is no exception. Even within the Latin American context, the country constitutes a most precarious case in terms of the availability of time-series data. Given these constraints, so far, there is very limited empirical research on virtually any macroeconomic topic in Guatemala. The lack of a

[1] Josef L. Loening is an economist at the World Bank, Washington DC, USA, and Research Associate at the Ibero-America Institute for Economic Research, University of Goettingen, Germany. E-mail: jloening@worldbank.org.

consistent compilation of data to allow a serious analysis of economic growth patterns has also hampered inter-temporal comparisons for the country (Loening 2005). Thus, a primary task for research is to overcome these information constraints. The paper shows how satisfactory and coherent time series can be obtained relatively easily, even in a data-scarce environment. This study, probably for the first time, constructs a reliable data set for the country that has proofed to be a useful tool to account for the determinants of long-run growth in Guatemala (Larrain 2004; and Loening 2004a, 2005).

The following sections describe in detail the baseline data and methodology to obtain time-series that are typically needed to analyze the determinants of long-run growth in a developing country. The standard baseline data sources to construct the time series are mainly from Banco de Guatemala, and, in the case of educational statistics, from the Ministry of Education (MINEDUC) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).[2] The remainder of the paper is organized as follows. Section 2 describes a methodology to come up with an estimate of the human capital stock. Section 3 shows how to derive a reasonable proxy for the labor force. Section 4 displays a methodology for an estimate of the physical capital stock. Building on the pervious results, section 5 constructs a simple quality index for capital and labor. Section 6 concludes and highlights some of the results that have been obtained from these estimates.

2. Human Capital Stock

The human capital stock of Guatemala is defined by average years of schooling evident in the labor force.[3] In line with most empirical analyses, this paper assumes that years of schooling provides a reasonable approximation of the human capital stock, although it

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[2] Other data sources are listed in Table 3 at the end of this article.

[3] The use of labor force instead of total population data is due to problems regarding the Guatemalan population data for the 1980s. By contrast, the labor force proxy used here is assumed to take into account some of the effects of the civil war (i.e., migration and displacement).

should be briefly stressed that the indicator is incomplete for several reasons.

(1) Education as proxy variable. Human capital is multifaceted and includes a complex set of human attributes. As a consequence, the genuine level of human capital is hard to measure in quantitative form. At best, average years of schooling can be regarded as a proxy for the component of the human capital stock obtained in schools.

(2) Quality changes. Average years of schooling measurements do not take into account quality changes within the education system. Quality changes may complicate comparison of schooling effects on growth over time as well as making comparisons with other countries difficult. Unfortunately, in terms of data availability, it proves impossible to obtain an index of quality changes of education for 1951-2002 in Guatemala. While there is cross-country evidence suggesting that education quality is more fundamental than quantity, for example in Barro (2001), it is believed here that this issue may be of minor relevance for this particular case study. That is, in a country where the quantity and quality of education is still very low, a human capital quality index is probably less important for analytical purposes.

(3) Aggregation bias. Average years of schooling raise human capital by an equal amount regardless of whether a person is enrolled in a primary, secondary or tertiary school. This is an important point because by defining human capital by average years of schooling, one implicitly gives the same weight to any year of schooling acquired by a person. This disregards the findings of the microeconomic literature on wage differentials. For example, Psacharopoulos and Patrinos (2002) suggest that the rates of return to education could be decreasing with the acquisition of additional schooling. Taking this argument into consideration, the following calculations also construct average years of schooling by level of education.

After making some modifications to account for the statistical circumstances in Guatemala, the following procedure for constructing estimates of the human capital stock is used, based on the attainment census method advocated by Barro and Lee (2001).

The use of a perpetual inventory method that employs census and survey information on educational attainment as benchmark figure can be seen as a major advantage over previous methodologies. The benchmarks are taken from various national censuses and surveys (Table 1). Guatemalan statistics report distributional attainment stratified by age and sex in five cases: no formal education, first cycle of primary, second cycle of primary, first cycle of secondary, second cycle of primary and tertiary education. The data has been summarized into 4 broad categories, that is, no school, some primary, some secondary and some tertiary education.

Table 1. Guatemala: Education Level of Labor Force, 1950-2002 (in percent)

Year	Source	No school	Some or all primary	Some or all secondary	Some or all tertiary
1950	SEGEPLAN (1978)	72.3	24.9	2.3	0.5
1964	SEGEPLAN (1978)	60.7	33.4	4.7	1.2
1973	SEGEPLAN (1978)	51.7	40.8	6.1	1.4
1981	DGE (1981)	(37.7)	(48.7)	(10.9)	(2.7)
1989	INE (1989)	38.9	47.7	11.4	2.1
1994	INE (1994)	35.4	47.8	14.1	2.7
1998	INE (1998)	(30.8)	(50.3)	15.9	3.1
2000	INE (2000)	28.9	48.6	16.5	6.0
2002	INE (04-05/2002)	26.9	49.3	19.3	4.5
2002	INE (08-09/2002)	24.7	50.8	19.3	5.2
2002	INE (10-11/2002)	25.0	48.7	21.0	5.3

Source: Compiled from census and survey data, INE (2000) and (2002) figures are from UNDP Guatemala. Brackets indicate uncertain figures; discrepancies are due to rounding.

The procedure starts to construct current flows of adult population, which are added to the initial benchmark stocks of the labor force (the benchmarks for 1950 are taken from the Barro and Lee 2001 data set). The formulas for the three levels of schooling for the labor force aged 15 and over are as follows:

(1) $$HN_{0,t} = HN_{0,t-1} \cdot (1 - d_t) + L15_t \cdot (1 - PRI_{t-1})$$

(2) $$HN_{1,t} = HN_{1,t-1} \cdot (1 - d_t) + L15_t \cdot (PRI_{t-1} - SEC_t)$$

(3) $$HN_{2,t} = HN_{2,t-1} \cdot (1 - d_t) + L15_t \cdot SEC_t - L20_t \cdot TER_t$$

(4) $$HN_{3,t} = HN_{3,t-1} \cdot (1 - d_t) + L20_t \cdot TER_t$$

where

HN_j	=	number of the economically active population for whom j is the highest level of schooling attained (j=0 for no school, j=1 for primary, j=2 for secondary and j=3 for higher education)
PRI	=	enrollment ratio for primary education
SEC	=	enrollment ratio for secondary education
TER	=	enrollment ratio for tertiary education
L	=	number of the economically active population
L15	=	number of persons aged 15
L20	=	number of persons aged 20
$\delta_{h,t}$	=	'mortality rate' of the human capital stock.

The 'mortality rate' for the economically active population aged 15 and over is estimated from:

(5) $$d_{h,t} \approx \frac{L_{t-1} - (L_t - L15_t)}{L_{t-1}}$$

And assumes that the mortality rate (which also includes the exit of the economically active population due to retirement or inactivity) is independent of the level of schooling attained, which is not entirely correct. The term $L_t – L15_t$ describes the number of survivals from the previous period, which are subtracted from L_{t-1} in order to estimate the total number of missing persons. Equation (5) as such describes the proportion of the labor force which did not survive from the previous period. The formulas can be rearranged to create the final equations that were used to generate the attainment ratios, hr_j, for the four broad levels of schooling for the economically active population aged 15 and over:

$$hr_{0,t} = \frac{HN_{0,t}}{L_t} = hr_{0,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (1 - PRI_{t-1}) \tag{6}$$

$$hr_{1,t} = \frac{HN_{1,t}}{L_t} = hr_{1,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (PRI_{t-1} - SEC_t) \tag{7}$$

$$hr_{2,t} = \frac{HN_{2,t}}{L_t} = hr_{2,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot SEC_t - \frac{L20_t}{L_t} \cdot TER_t \tag{8}$$

$$hr_{3,t} = \frac{HN_{3,t}}{L_t} = hr_{3,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L20_t}{L_t} \cdot TER_t \tag{9}$$

The procedure requires school enrollment ratios that are crucial for exact calculations, but the proper accounting for Guatemala is not easy. Even though net enrollment ratios would be more precise for estimating the accumulation of human capital, gross enrollment ratios are used, as only this data is available. As reported in Table 1, the ratios are taken from various yearbooks of MINEDUC for the 1990s, UNESCO for earlier periods, and other sources available for Guatemala. The data for primary, secondary and tertiary enrollment ratios have been found consistent over time. Interpolation techniques were used to fill gaps in the data, but the use of this approach was kept to a minimum. The tertiary enrollment time series were more difficult to compile and required greater use of interpolated estimates.

In general, the estimated attainment data compares favorably with the census and survey information. The less accurate fit for 1981 is here believed to be due to large measurement errors or the possible manipulation of the census, which took place during the peak of the armed conflict in Guatemala. Consequently, this discrepancy was not smoothed over. Equally, data for 1998 differs slightly from the estimate. This is due to the fact that the survey largely oversamples the urban population of the economy in that year. Given the simplicity of the assumptions of the underlying model, however, the overall results have been found quite satisfactory.

In any case, simply employing gross enrollment ratios would overestimate the accumulation of human capital.[4] Gross enrollment ratios are defined as the ratio of total enrollment in the respective schooling level to the population of the age group that is expected to be enrolled at that level. Thus, gross enrollment ratios can exceed 1 and therefore exaggerate the true amount of enrollment when students repeat, which is often the case in Guatemala. In response to this problem and in order to benchmark the estimated educational attainment data with census and survey information, the gross enrollment ratios have been adjusted by a depreciation factor for the respective education level, as reported in Loening (2004b).

Finally, the formula to construct the measure for the human capital stock combines the estimated attainment data with the information on the duration of each schooling level. It is given as:

[4] The use of net enrollment ratios is hampered by large data gaps. Also, net enrollment ratios introduce large measurement errors if there are under- or over-aged children starting at each level of education, see Barro and Lee (2001). In Guatemala students who start late constitute a significant fraction of total enrolment, in particular for primary schooling.

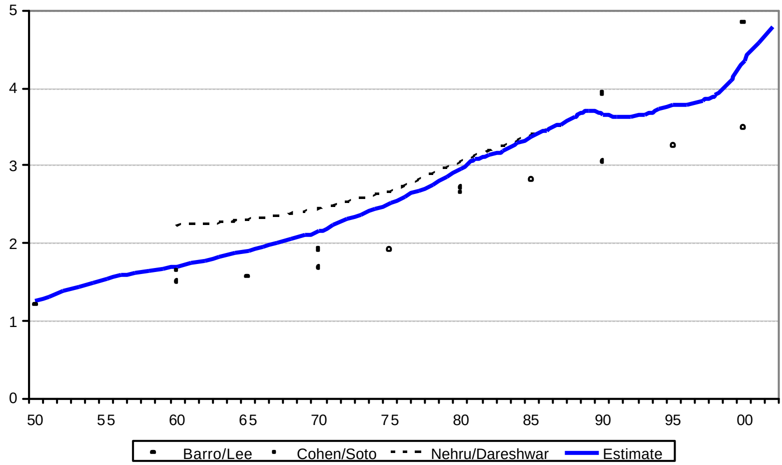
$$h_t = \sum_{j=1}^{3} hr_{j,t} \cdot d_{j,t} \qquad (10)$$

where h_t stands for the average years of schooling, hr_j is the estimated attainment ratio of the labor force and d_j is the average number of years of education received in the respective schooling level j. Average education values have been calculated from the INE (1989) household survey and are assumed to have remained constant over time. This may result in a slight overestimate of the human capital stock for the period prior to 1989 and underestimate the average years of schooling for later periods. However, data from more recent household surveys suggest that this assumption may not be a large source of error.

How do these calculations compare to other sources? Figure 1 compares the results between the estimated average years of schooling here and those provided by Cohen and Soto (2002), Barro and Lee (2001), and Nehru et al. (1995), using different techniques and data sources.

The time series shown by the solid line harmonizes to a large extent with alternative estimates at different points of time. Unlike the Barro and Lee data set, there is no implausible jump for 1980. The Cohen and Soto (2002) estimate provides the closest approximation. Additionally, not shown by Figure 1, the average years of schooling estimates here come close to values obtained from census and survey data. For example, Psacharopoulos and Arriagada (1986) report that mean education in the labor force was in the order of 1.7 for 1964. Edwards (2002) reports a value of 4.3 years for 2000. According to the estimate here, average years of schooling was in the order of 1.9 years in 1964 and 4.4 in 2000.

Figure 1. Guatemala: Average Years of Schooling in Labor Force, 1950-2002



Source: Author's estimate, and Barro and Lee (2001), Cohen and Soto (2001), Nehru et al. (1995) education data.

A closer look at Figure 1 yields two important descriptive outcomes. First, the data suggests that mean education evident in the labor force slightly declined during the early 1990s. This outcome is associated with the disastrous effect of the civil war on the country's human capital base. Those disadvantaged cohorts from the 1980s entered later into the labor force. Second, there has been substantial increase in the average years of schooling within the economically active population since 1998. This can be attributed to improvements within the education system and increased attention to education after the signing of the 1996 Peace Accords.

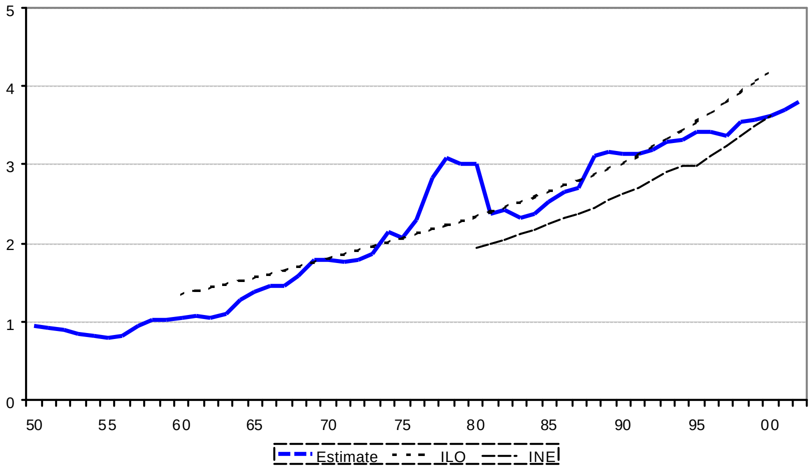
2. Labor Force

The measure of labor quantity here is the economically active population. For Guatemala there are several estimates. The National Statistic Institute (INE) provides calculations different from those of the Ministry of Work, both of which date back to 1980. Based on census and survey data, estimates for selected years have also been provided by the United Nations Development Programme (UNDP) for Guatemala. The labor force is usually defined as the working and job-seeking population, but the different calculations do not always reveal what underlies the specific assumptions and age definitions used for calculations. To develop a consistent time series of the economically active population, the International Labor Organisation (ILO) has used information on age specific labor force participation rates and population statistics. Unfortunately, for the reasons clarified below, these estimates are unreliable.

(1) Data discrepancies. First, there is no agreement either on the level or on the growth rates of the labor force. Virtually all data is different from each other. For example, UNDP (2003) reports a total labor force estimate of about 2.84 million for 1989, as compared to 2.54 million from INE or 2.95 million from ILO. Second, as typical for estimates in other countries, labor force data should show some cyclical fluctuations as labor responds to higher output growth. Official estimates for Guatemala, however, are remarkably free of *any* fluctuations and follow a monotonous trend. This suggests reliance on population statistics or use of interpolation techniques.

(2) Omission of the civil strife. Most importantly, these estimates do not take into account migration flows and the consequences of the civil war on the economically active population. Especially the last point devalues official estimates. According to the Commission for Historical Clarification (1999), the internal military conflict left an estimated 200,000 civilians dead and another 1 million displaced, for a total population of about 10 million. Such an immense impact of the civil strife should be reflected somewhere in the statistics? but it is not.

Figure 2. Guatemala: Labor Force, 1950-2002 (millions of workers)



Source: Author's estimate based on Banco de Guatemala (2003), INE and ILO data.

In the absence of reliable information about the economically active population from these sources, labor is here proxied by the number of private contributors to the Guatemalan Social Security System (IGSS). The reliance on the number of private contributors to the Social Security System in order to account adequately for the economically active population is also adopted in an IMF study for the case of El Salvador by Morales (1998), and for Guatemala by Prera (1999). The numbers representing the labor force are calculated by assuming that the social security contributors account for approximately 25 percent of the total labor force.[5] The participation rate has a negligible impact on the later calculations and is based on a historical mean value.

Although a broad approach may limit the precision of calculations, regression analysis from Loening (2004a, 2005) and Larrain (2004)

[5] UNDP (2003) reports a participation rate of 24.5 percent (2002). Based on INE data, as reported by Global Info Group (1999), this compares to 27.6 percent (1995), 29.9 percent (1990) and 28.2 percent (1985).

clearly show that the variable has a high explanatory power on growth. Moreover, as can be seen from Figure 2, the estimated values give a more reasonable picture than the data from official sources. Notice that the *level* of the economically active population, but not its growth rate, is basically in line with ILO or INE calculations. In 1980s, when the civil war had already taken genocide proportions, the labor force dropped dramatically by about 660,000.[6] For recent years, the estimate for the economically active population derived from IGSS statistics comes close to INE data.

3. Physical Capital Stock

Internationally, the Perpetual Inventory Method (PIM) is a common way to estimate capital stock, but there are uncertainties associated with the calculation. In general, due to the lack of information about the initial capital stock, questionable validity of assumptions about the rate of depreciation, and lack of information about the utilization of capital, estimates should be taken with care. With these reservations in mind, the PIM was used to construct the physical capital stock for Guatemala. The following paragraphs present two distinct calculations, one with aggregated and another with disaggregated investment data.

(1) Aggregated investment data. The physical capital stock for the period 1950-2002 is computed using the PIM with aggregated investment data. The procedure argues that the stock of capital is the accumulation of the stream of past investments:

(11) $$K_t = K_{t-1} \cdot (1 - d_K) + I_t$$

where K is the capital stock, I gross fixed capital formation, d_K the annual depreciation rate of the capital stock, and t an index for time. The initial value of the capital-output ratio for 1950 is taken from the

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[6] It should be emphasized that the reliance on IGSS data may understate the drop of the economically active population during the 1980s. This is because the working population in the informal and rural sectors (typically not captured by the social security system) was particularly affected by violence and displacement policies.

Nehru and Dhareshwar (1993) data set.[7] Information about gross fixed capital formation was provided directly by the Economic Research Department of the Banco de Guatemala. The data is compiled using the somewhat dated 1953 UN System of National Accounts, which is currently under revision.[8]

In line with other studies for Latin America, such as Loayza et al. (2004) and Morales (1998), the overall depreciation rate is assumed at 5 percent. This is still a rather high estimate when compared with more commonly used thumb values. However, regarding the armed conflict, which has lasted for 36 years, and several periods of high violence in Guatemala, it was found useful to adopt a high depreciation rate in order to account for both capital destruction and distraction from productive use. For example, the latter may have resulted in unprofitable military spending, several forms of non-productive investments, or temporary spare capital because of infrastructure deficiencies.

(2) Disaggregated investment data. Based on the PIM, Morán and Valle (2002) present a second approach for Guatemala. In their model the capital stock is estimated for eight broad asset groups for 1971-2000. However, presumably because of too high depreciation rates for public and private construction, they seem to underestimate the genuine level of the capital stock. Following their methodology but applying different depreciation rates and taking into account the initial benchmark estimate from Nehru and Dareshwar (1993), a second capital stock series has been calculated with disaggregated investment data for the period 1970-2002.

The initial values are obtained from a pre-estimate starting in 1950. The data gaps for the sectoral composition of the eight assets groups

[7] The potential error of the estimate of initial capital stock diminishes over time due to depreciation. Based on international data, Nehru and Dhareshwar (1993) offer an estimate of the capital stock for Guatemala that was taken as a benchmark.

[8] UNDP (2002) provides a brief summary of the associated empirical consequences and causes that prevented an actualization of the Guatemalan National Accounts.

prior to 1970 are filled in by extrapolation techniques. These values, however, only provide reasonable initial values for the disaggregated capital stock. Table 2 presents the assumed average life service lines for each of these assets groups. The average service life for a given class of asset is considered to be identical for all kinds of economic activities. The service lives are arrived at by considering the nature of these asset groups, consulting experts, and a careful review of the average service lives used by other countries, as reported in OECD (2001).

Table 2. Guatemala: Asset Classes and Average Service Lives

Asset Class	Average Service Life (Years)	
	Private Sector	Public Sector
Construction	50	50
Machinery and Equipment	...	15
Imported Capital Goods	15	...
Domestically Produced Capital Goods	10	...
Cultivated Assets and Major Improvements to Land	6	...
Other Assets	10	...

Source: Based on OECD (2001) and expert consultation.

Based on average service life estimates, geometric depreciation rates are applied. With geometric depreciation, the market value in constant prices is assumed to decline at a constant rate within each period. The implicit depreciation factor for each asset group is set at a value that ensures that the initial value will have been reduced to 10 percent of the original value by the time it reaches the end of its expected service life. The main drawback of geometric depreciation is that it will never exhaust the full value of an asset. That is, the depreciated value of the asset falls asymptotically, approaching, but never reaching, zero. While the infinity problem is somewhat troublesome, geometric depreciation has the practical advantage of being suited better for benchmark estimates, such as in the present study.

5. Quality Indices of Capital and Labor

Based on the previous calculations, quality indices can be elaborated. A quality index of the labor force and capital stock is often a useful requirement for extended growth accounting exercises. The following paragraphs are concerned with the construction of the indices for the quality of capital and labor, respectively, and a brief comparison over both indices for 1970-2002. Finally, a discussion reveals that the capital and labor quality indices yield interesting outcomes.

(1) Quality index of capital. One can calculate a quality index of capital by using the disaggregated capital stock data. The estimate follows the methodology advocated by Laurits et al. (1980) and Roldós (1997). For the case of Guatemala, this means that changes in the index of quality of capital, *zq*, are computed as a weighted average of investment of the four broad asset groups. These are (1) public and private construction, (2) imported capital goods and investment in machinery and equipment, (3) domestically produced capital goods, and (4) cultivated assets and major improvements to land. The formula used is:

(12) $$\Delta \log zq_t = \sum_{i=1}^{4} v_{i,t} \cdot (\Delta \log K_{i,t-1}) - (\Delta \log K_{t-1})$$

where K_i is the respective capital stock and the weights v_i are the relative capital rental rates. The index reflects changes in the composition of capital. If *all* components of the capital stock are growing at the same rate, quality remains unchanged. If *components* of the capital stock with higher capital rents are growing more rapidly, quality increases. Since data on the rental rates v_i is not readily available for Guatemala, estimates of these are, following Roldós (1997), based on the arbitrage relation:

(13) $$v_{i,t} = (1 + r_t) \cdot P_{i,t} - (1 - d_{Z,i}) \cdot P_{i,t+1}$$

where P_i is a price index, $d_{Z,i}$ the depreciation rate, and r_t is the economy-wide real interest rate. The price indices for the respective asset groups are taken from the Morán and Valle (2002) database. In order to take into account the volatility of the real exchange rate, which affects directly the relative price of the four types of capital, and to correct for measurement bias, the final series are smoothed by a 3-year moving average.

(2) Quality index of labor. To quantify labor quality, an index hq is computed as a weighted average of labor within different levels of education. This formulation is consistent with the growth accounting literature that makes adjustments for education. It allows a more accurate indication of the contribution of labor to production. The index hq is defined as follows:

$$hq_t = \sum_{j=1}^{3} w_j \cdot (L_{j,t} / L_t) \tag{14}$$

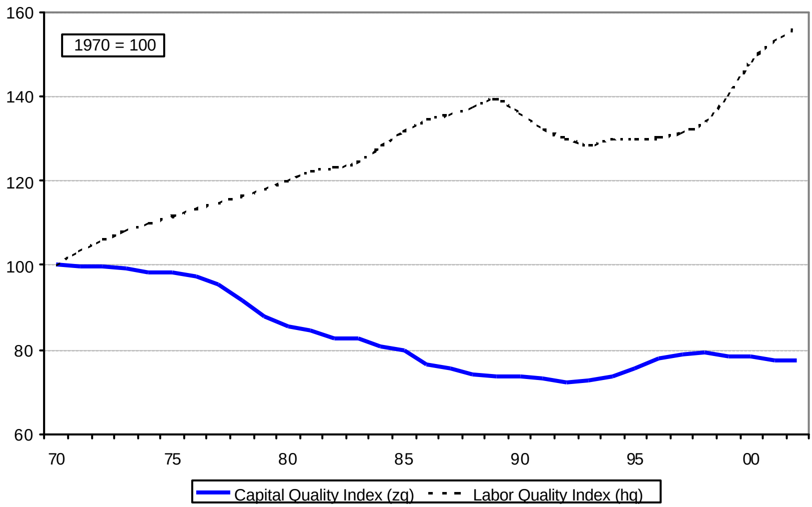
where L_j is the labor force with education level j (primary, secondary and tertiary) and w_j are the weights for the respective schooling level. The weights measure how the productivity effect of schooling varies with the level of education and are taken from Loening (2005, Table 6). Interestingly, they correspond approximately with the private returns to schooling at each education level, as presented by Psacharopoulos and Patrinos (2002) for Guatemala.

Figure 3 compares the estimated indices of the quality of labor, hq, and capital, zq. The descriptive analysis yields three important outcomes. First, the index of labor quality presents a clear upward trend, reflecting improvements in educational capital and a shift to more skilled jobs. However, as a consequence of the civil strife, labor quality slightly declined during the early 1990s but begins to increase again after 1998.

Second, the quality of capital has decreased over time. In particular after 1977, the data suggests that capital quality declined dramatically. In the mid 1990s, the advent of the Peace Accords led to an improvement, followed, however, by a stagnant pattern. In any case, for the period under observation, the quality of Guatemala's capital stock declined by about 20 percent. The exact reasons underlying the deterioration are unclear and require further research. Prominent explanations are the destructive impact of the internal military conflict, and a negative investment climate due to an unstable policy environment and lack of good governance. Changes in capital quality may reflect the fact that investment with comparatively higher rental rates (imported capital goods as well as machinery and equipment) decreased during the civil war but eventually climbed up again.

Third, a comparison of both indices shows an apparent gap between the evolution of the quality of capital and the quality of labor. This could imply that the deterioration of quality of capital is associated with, among other factors, the decreased output growth during the last decades. In other words, there is a missing complementarity between the country's skills and its technology base.

Figure 3. Guatemala: Indices of Capital and Labor Quality, 1970-2002 (in percent, relative to base year 1970)



Source: Author's calculations.

6. Conclusion and Empirical Applications

This paper shows how coherent time series can be obtained relatively easily in the context of a developing country with usual data limitations. Measures include the approximation of the labor force, an estimate of the physical capital stocks with aggregated and disaggregated investment data, and an index for the quality of labor and physical capital. A particular focus is placed on the construction of the human capital stock. A modification of the methodology of Barro and Lee (2001) shows that time-series data can be constructed for an individual country even in a data-scarce environment. As such, the results of this paper may be useful for data-generating exercises in developing countries which similar constraints, even beyond this particular case.

The data set produced here that has proofed to be a useful tool to analyze the determinants of long-run growth in Guatemala. For example, accounting for the sources of growth suggests that human capital has been a key determinant of growth in Guatemala. Loening (2005) find that an increased skill level has been the main driving force behind productivity growth, and that education explains about 50 percent of output growth during the past five decades. Due to an environment of social and political conflict, however, total factor productivity has been slightly negative over the past decades.

In addition, regression analysis in Loening (2004a, 2005) shows that human capital has a highly significant and positive impact on long-run growth in Guatemala. The effect is of similar magnitude to that in micro studies. Also Larrain (2004) uses this dataset as a starting point for his growth regressions. Overall, the results of these studies have been found robust with respect to data issues. The robustness is even more remarkable in the context of heavy distortions within the Guatemalan economy.

References

Banco de Guatemala (2003), *Empleos y salarios: estadísticas del Instituto Guatemalteco de Seguridad Social, años 1960-2002*. Departamento de Estadísticas Económicas, Sección de Análisis de Mercado y Comercio Exterior, Guatemala, processed.

Barro, R. J. (2001), "Human Capital and Growth", *American Economic Review*, Vol. 91, No. 2, pp. 12-17.

Barro, R. J. and J.-W. Lee (2001), "International data on educational attainment: updates and implications", *Oxford Economic Papers*, Vol. 53, No. 3, pp. 541-563.

CEPAL (Comisión Económica para América Latina) and CELADE (Centro Latinoamericano de Demografía), División de Población (2000), "Guatemala: estimaciones y proyecciones de la población de ambos sexos por años calendarios y edades simples 1950-2050", *Boletín Demográfico* 66.

Cohen, D. and M. Soto (2001), "Growth and human capital: Good data, good results", *Technical Paper* 179, OECD Development Centre, Paris.

Commission for Historical Clarification (1999), *Guatemala: memoria del silencio*, Guatemala, United Nations Office for Project Services.

DGE (Dirección General de Estadística) (1981), *Censos Nacionales: IV Habitación y IX Población, Características Generales*, Guatemala, published 1984.

Edwards, S. (2002), "Education and Poverty in Guatemala", *Technical Paper* 3, Guatemala Poverty Assessment Program, World Bank, Washington D.C., processed.

Global Info Group (1999), *En Cifras: Guatemala, perfil integral del país*, Guatemala and Miami, processed.

INE (1994), *X Censo Nacional de Población y V de Habitación: Características Generales de Población y Habitación*, Guatemala, published 1996.

INE (1998), *ENIGFAM – Encuesta Nacional de Ingresos y Gastos Familiares*, Guatemala, Instituto Nacional de Estadística.

INE (2000), *ENCOVI – Encuesta Nacional sobre Condiciones de Vida*, Guatemala, published 2002 (the data here is from UNDP).

INE (2002), *ENEI – Encuesta Nacional de Empleo e Ingresos*, Guatemala, published 2002-2003 (the data here is from UNDP and comes in three volumes: ENEI 1, 2 and 3).

INE (Instituto Nacional de Estadística) (1989), *ENS – Encuesta Nacional Socio-Demográfica*, Guatemala (calculations are based on a database from UNDP/CEPAL).

Larrain, F. (2004), "Guatemala: los desafíos del crecimiento", *Series de Estudios Económicos y Sectoriales* RE-2-04-001, Washington, D.C., Inter-American Development Bank.

Laurits R., D. Cummings and D. W. Jorgenson (1980), "Economic Growth, 1947-73: An International Comparison", in J. W. Kendrick and B. N. Vaccara (eds.), *New Developments in Productivity Measurement and Analysis, Studies in Income and Wealth*, Vol. 44, Chicago, University of Chicago Press.

Loayza, N., P. Fajnzylber and C. Calderón (2004), "Economic

Growth in Latin America and the Caribbean: Stylized Facts, Explanations and Forecasts", Banco Central de Chile, *Documento de Trabajo* 265.

Loening, J. L. (2004a), "Human Capital, Technology Diffusion and Economic Growth in a Low-to-Middle Income Country: A Time Series Perspective", *Applied Econometrics and International Development*, Vol. 4, No. 3, pp. 1-18.

Loening, J. L. (2004b), "Determinants of Economic Growth in Guatemala", in C. Dreger and G. Hansen (eds.), *Advances in Macroeconometric Modeling*. Baden-Baden, Nomos Verlagsgesellschaft, pp. 117-148.

Loening, J. L. (2005), "Effects of Primary, Secondary and Tertiary Education on Economic Growth: Evidence from Guatemala", *World Bank Policy Research Working Paper* 3214.

Ministerio de Educación (MINEDUC), Unidad de Informática (various years), *Anuario estadístico de la educación*, Guatemala, processed (issues for 1991-2000 in printed version, data for 2001 on CD-ROM, preliminary data for 2002 comes directly from the ministry's statistical unit).

Ministerio de Educación and SEGEPLAN (Secretaría General del Consejo Nacional de Planificación Económica) (1980), *Datos estadísticos de la educación primaria rural urbana en Guatemala: situación actual y proyecciones*, Guatemala, processed.

Mitchell, B. R. (1998), *International Historical Statistics: The Americas 1750-1993*, London, Macmillian.

Morales, R. A. (1998), "Determinants of Growth in an Error-correction Model for El Salvador", *IMF Working Paper* 98/104.

Morán, I. E. and H. A. Valle (2002), "Tres métodos alternativos para la estimación del PIB potencial: una estimación para Guatemala", *Banca Central*, Vol. 11, No. 1, pp. 97-112.

Nehru, V. and A. Dhareshwar (1994), "New Estimates of Total Factor Productivity Growth for Developing and Industrial Countries", *World Bank Policy Research Working Paper* 1313.

Nehru, V., E. Swanson and A. Dubey (1995), "A New Database on Human Capital Stock in Developing and Industrial Countries: Sources, Methodology and Results", *Journal of Development Economics*, Vol. 42, No. 2, pp. 379-401.

OECD (2001), *Measuring Capital: A Manual on the Measurement of*

Capital Stocks, Consumption of Fixed Capital and Capital Services, Paris, processed.

Prera, M. (1999), *Estimación de una función de producción para Guatemala*, Tesis de Licenciatura en Economía, Facultad de Ciencias Económicas, Universidad Francisco Marroquín, Guatemala, processed.

Psacharopoulos, G. and A. M. Arriagada (1986), "The Educational Composition of the Labor Force: An International Comparison" International Labor Review, Vol. 125, No. 5, pp. 561-574.

Psacharopoulos, G. and H. A. Patrinos (2002), "Returns to Investment in Education: A Further Update", *World Bank Policy Research Paper* 2881.

Roldós, J. (1997), "Potential Output Growth in Emerging Market Countries: The Case of Chile", *IMF Working Paper* 97/104.

SEGEPLAN (Secretaría General del Consejo Nacional de Planificación Económica), Unidad de Empleo y Población (1978), *Cuadros estadísticos de población y PEA: censos 1950, 1964 y 1973*, Guatemala, processed.

UNDP (2003), *Guatemala: una agenda para el desarrollo humano*, Informe Nacional del Desarrollo Humano 2003, Guatemala, Sistema de las Naciones Unidas en Guatemala.

UNDP (United Nations Development Programme) (2002), *Guatemala: desarrollo humano, mujeres y salud*, Informe Nacional del Desarrollo Humano 2002, Guatemala, Sistema de las Naciones Unidas en Guatemala.

UNESCO (1958), *World Survey of Education*, Part II: Primary Education. Paris.

UNESCO (1961), *World Survey of Education*, Part III: Secondary Education. Paris.

UNESCO (1966), *World Survey of Education*, Part IV: Higher Education, Paris.

UNESCO (United Nations Educational, Scientific and Cultural Organization) (1955), *World Survey of Education*, Paris.

UNESCO (various years), *Statistical Yearbook*, Paris.

World Bank (2003), *World Development Indicators*, CD-ROM, Washington D.C.

Appendix

Table 3. Guatemala: Data Sources of Time Series

Variables	Abbrev.	Source
Gross domestic product (GDP) (in 1958 Quetzals)	Y	Banco de Guatemala.
Capital stock (in 1958 Quetzals)	K	Perpetual inventory estimates, see text.
Gross fixed capital formation (in 1958 Quetzals)	I	Banco de Guatemala.
Average schooling (years)	H	Perpetual inventory estimates, see text.
Participation of primary, secondary and tertiary education in labor force	hr_{pri} hr_{sec} hr_{ter}	Perpetual inventory estimates, see text.
Population statistics (15 and 20 year old, 15-64 year old)	L15 L20 L15-64	CEPAL and CELADE (2000).
Labor force, total	L	Derived from the number of private contributors to the IGSS, see text. Data for 1960-2002 is taken from Banco de Guatemala (2003). Data for 1955-1959 is obtained directly from IGSS. Missing values for 1950-1954 were derived from SEGEPLAN (1978).
Primary and secondary gross enrollment ratios	PRI SEC	For 1960-1990 UNESCO estimates as reported in World Bank (2003). For 1991-2002 Ministerio de Educación (various years) and UNDP (2002). Primary gross enrollment ratios are that of nivel primaria. Secondary gross enrollment ratios are that of

		nivel básico. Missing values were completed with information provided in UNESCO (1958, 1961, 1966, various years), Mitchell (1998) and Ministerio de Educación and SEGEPLAN (1980).
Tertiary gross enrollment ratio	TER	For 1960-1987 UNESCO estimates as reported in World Bank (2003). Missing values were either interpolated or completed with information provided in Mitchell (1998), UNESCO (1966) and UNESCO (1958, 1961, 1966, various years). For 1988-2002 ratio of students at San Carlos University (USAC) to the number of persons aged 20-24, as reported in Global Info Group (1999) and UNDP (2003).
Annual rental rates	vi,t	Calculations are based on Morán and Valle (2002) data set for implicit price estimates, and Banco de Guatemala for disaggregated gross fixed capital formation and real interest rates.
Physical capital quality index	zq	Estimated, see text.
Labor quality index	hq	Author's calculations, see text. The weights are taken from Loening (2005) Table 6.

Table 4. Guatemala: Time Series, 1950-2003

Year	Y	I	$K_{d=0.05}$	$K_{DISAGGREGATED}$	L	H_{TOTAL}	H_{PRI}	H_{SEC}	H_{TER}	zq	hq
	Thousand of 1958 Quetzals				Workers	Years				Indice (1970=100)	
1950	722344	81670	1086913	…	947442	1.2492	0.9510	0.2257	0.0725	…	…
1951	732525	79933	1112501	…	917001	1.3145	0.9985	0.2624	0.0536	…	…
1952	747724	68940	1125815	…	886560	1.3741	1.0401	0.2931	0.0410	…	…
1953	775292	67590	1137115	…	856118	1.4297	1.0774	0.3196	0.0327	…	…
1954	789610	67039	1147298	…	825677	1.4826	1.1118	0.3433	0.0274	…	…
1955	809107	90420	1180353	…	795236	1.5342	1.1444	0.3640	0.0258	…	…
1956	882711	142481	1263816	…	814288	1.5832	1.1738	0.3812	0.0282	…	…
1957	932494	154221	1354847	…	944152	1.6178	1.1908	0.3947	0.0323	…	…
1958	976055	136315	1423419	…	1022192	1.6474	1.2028	0.4073	0.0373	…	…
1959	1024223	125518	1477766	…	1020088	1.6769	1.2129	0.4195	0.0445	…	…
1960	1049199	107812	1511690	…	1056400	1.7044	1.2213	0.4331	0.0501	…	…
1961	1094267	113473	1549578	…	1076260	1.7363	1.2289	0.4521	0.0554	…	…
1962	1132984	108678	1580778	…	1059536	1.7777	1.2416	0.4755	0.0606	…	…
1963	1241064	128805	1630544	…	1099352	1.8231	1.2571	0.5008	0.0653	…	…
1964	1298557	157790	1706807	…	1289156	1.8656	1.2722	0.5241	0.0693	…	…
1965	1355156	166770	1788236	…	1382076	1.9100	1.2885	0.5483	0.0732	…	…
1966	1429923	165886	1864710	…	1467784	1.9485	1.3056	0.5647	0.0782	…	…
1967	1488609	184262	1955737	…	1469604	1.9958	1.3349	0.5768	0.0841	…	…
1968	1619203	209430	2067380	…	1583232	2.0456	1.3703	0.5851	0.0902	…	…
1969	1695892	212709	2176720	…	1786160	2.0946	1.4076	0.5906	0.0963	…	…
1970	1792754	209627	2277511	1507503	1793104	2.1485	1.4503	0.5949	0.1033	1.0000	1.0000
1971	1892832	227404	2391040	1578744	1771368	2.2250	1.4974	0.6147	0.1129	0.9994	1.0328
1972	2031552	226112	2497600	1639457	1793512	2.3016	1.5322	0.6448	0.1247	0.9964	1.0597
1973	2169378	251898	2624618	1720205	1875452	2.3758	1.5576	0.6806	0.1377	0.9912	1.0816
1974	2307675	247192	2740579	1787923	2159168	2.4418	1.5753	0.7164	0.1501	0.9816	1.0987
1975	2352750	270567	2874117	1868717	2082784	2.5142	1.5912	0.7588	0.1642	0.9809	1.1158
1976	2526537	371393	3101804	2041764	2311680	2.5951	1.6038	0.8123	0.1790	0.9727	1.1325
1977	2723844	405798	3352512	2231771	2835260	2.6725	1.6136	0.8664	0.1925	0.9559	1.1476
1978	2859913	435653	3620539	2432628	3076180	2.7557	1.6229	0.9265	0.2063	0.9146	1.1632
1979	2994650	413362	3852874	2590383	3024684	2.8515	1.6327	0.9971	0.2217	0.8798	1.1809
1980	3106877	372592	4032822	2695595	3022168	2.9561	1.6428	1.0749	0.2383	0.8568	1.1998
1981	3127560	401472	4232654	2825652	2364076	3.0784	1.6559	1.1676	0.2548	0.8451	1.2230
1982	3016573	357665	4378686	2905846	2436576	3.1313	1.6578	1.2073	0.2662	0.8283	1.2308
1983	2939604	258193	4417945	2886537	2334192	3.1897	1.6677	1.2470	0.2749	0.8282	1.2434
1984	2953546	234936	4431984	2851393	2379744	3.2845	1.7196	1.2852	0.2797	0.8086	1.2818
1985	2936062	220153	4430537	2807024	2526616	3.3699	1.7653	1.3172	0.2874	0.7978	1.3156
1986	2940175	228558	4437568	2777645	2641776	3.4601	1.7976	1.3692	0.2933	0.7668	1.3440
1987	3044395	266133	4481822	2790849	2715980	3.5304	1.8023	1.4305	0.2977	0.7570	1.3565
1988	3162873	299826	4557557	2836354	3118240	3.6169	1.8135	1.5029	0.3006	0.7434	1.3746
1989	3287594	318903	4648582	2897929	3153468	3.7140	1.8207	1.5929	0.3004	0.7377	1.3929
1990	3389552	286160	4702313	2922700	3143012	3.6651	1.7876	1.4722	0.4053	0.7355	1.3588
1991	3513627	296816	4764013	2956478	3147612	3.6331	1.7388	1.4172	0.4771	0.7309	1.3234
1992	3683616	385212	4911025	3073939	3182832	3.6352	1.6989	1.4082	0.5280	0.7244	1.2996
1993	3828260	411831	5077304	3203916	3292956	3.6539	1.6663	1.4283	0.5593	0.7255	1.2838
1994	3982682	401038	5224477	3309285	3321296	3.7266	1.6800	1.4568	0.5898	0.7367	1.2981
1995	4179767	435901	5399154	3437740	3422384	3.7709	1.6717	1.4868	0.6124	0.7563	1.2986
1996	4303395	427259	5556456	3545515	3408972	3.7924	1.6739	1.4895	0.6290	0.7780	1.3012
1997	4491199	523411	5802044	3743701	3377628	3.8421	1.6852	1.5176	0.6393	0.7889	1.3130
1998	4715468	614623	6126565	4017746	3548912	3.9122	1.7221	1.5317	0.6584	0.7925	1.3391
1999	4896875	650313	6470550	4297213	3572504	4.0852	1.8070	1.5927	0.6855	0.7851	1.4026
2000	5073597	593028	6740050	4492524	3632488	4.3632	1.8960	1.7491	0.7181	0.7842	1.4836
2001	5191941	603899	7006946	4674313	3711072	4.5760	1.9291	1.9071	0.7397	0.7769	1.5294
2002	5308677	634792	7291391	4866308	3812208	4.7837	1.9397	2.0890	0.7550	0.7746	1.5645
2003	5434976	631332	7558153	5030231	…	…	…	…	…	…	…